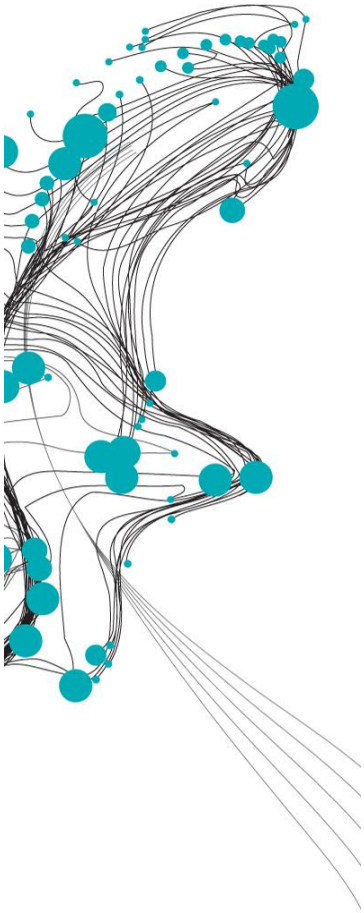
Interdependency of Stochastic Variables Determining Normative Water Levels in the Alblasserwaard



The Netherlands has always been vulnerable to floods due to its low elevation. To reduce the probability of floods in regional water systems to an acceptable level of safety, norms based on the probability of occurrence of these floods have been introduced. For each section in a regional water system, the water levels with a certain probability of occurrence (e.g. once in 100 years) are generally determined using a hydraulic model of the water system. This could be used to determine the required top level of regional flood defences. If the stochastic method is used to determine these normative water levels, a large number of events with known probability are used as input for the hydraulic model. It is generally assumed that the relevant stochastic variables (e.g. precipitation volume and wind speed) are independent of each other. However, it could be possible that there are dependencies present between these stochastic variables, which might affect the normative water levels. For example, the wind speed and/or the external water level (affecting the pumping stations) are potentially higher during precipitation events.

These dependencies and their potential effects on the normative water levels are assessed in a case study for the Alblasserwaard, a polder water system located in the west of the Netherlands (see Figure 1). First, the presence of dependencies between the stochastic variables is explored. Secondly, the effects of these dependencies on the joint probabilities are analysed using copulas. Copulas are functions which describe dependence structures, which can be used to construct joint probability distributions with high flexibility. Lastly, the joint probability distributions are used to determine the normative water levels in the Alblasserwaard and compared to the independent case.

The resulting differences between the normative water levels of the dependent and independent cases for a return period of 100 years are visible in Figure 1. These differences are a result of the dependencies between the precipitation volume, wind speed and external water level of the Lek (affecting the pumping station at Kinderdijk). Differences up to 12 cm close to the pumping station are found. In the rest of the area, the differences are smaller (maximum up to 6 cm).

This study shows that it is possible and technically feasible to account for interdependencies to determine normative water levels using copulas. It shows that the normative water levels can be affected by these dependencies, although the effects differ based on location and return period. Therefore, dependencies should not simply be neglected as it could potentially cause under-dimensioning of flood defences.

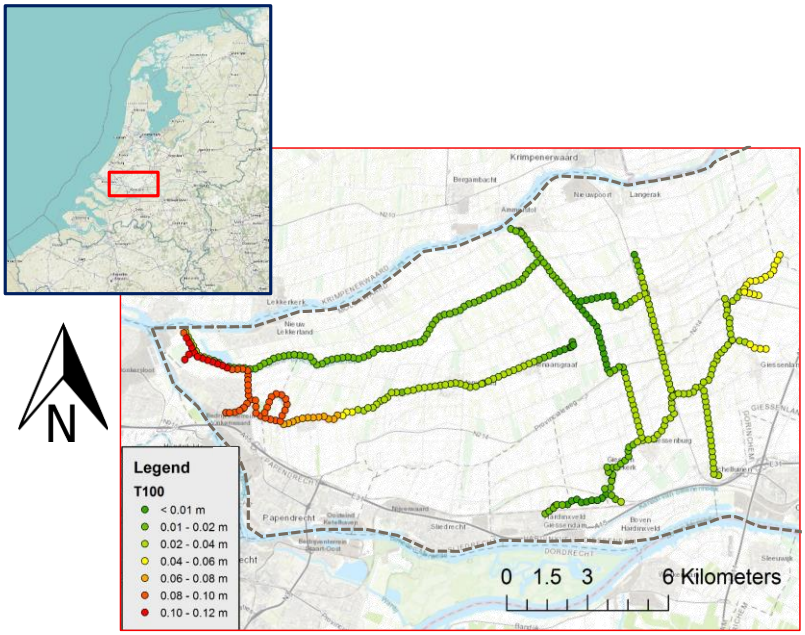


Figure 1: Differences in normative water levels between the dependent and independent situation in the Alblasserwaard area considering all the interdependencies with a return period of 100 years (T100). A positive difference means that the modelled dependent situation has higher normative water levels than the independent case.

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